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(54) Detachable connecting group for ribbon optical fibers and method of making the same.

(57) It is described a detachable connecting group for ribbon-joined optical fibers comprising two connectors (1, 2) integral to the ends of respective optical fiber ribbons (3, 4), in which each connector (1, 2) consists of a pair of coupled metal plates (5) rigidly fastened to each other, between which two or more optical fibers (7) belonging to a ribbon (3, 4) made of parallel optical fibers are clamped as well as alignment plug means (10), at least a plate (5) in each connector (1, 2) comprising an element made of metallic material in which several housing grooves (6, 9) for the optical fibers (7) of the ribbon (3, 4) and for the alignment plug means (10) are formed by cold plastic deformation using the same punch for all the plates belonging to one series. The method of accomplishing the invention provides the following steps: making several grooved plates (5) by plastic deformation using a single punch; coupling a grooved plate (5) to a second plate and interposing therebetween the optical fibers (7) being part of an optical fiber ribbon (3, 4) and on a length of which the common coating has been removed, partially housing the fibers (7) in the respective grooves (6); inserting a metered amount of hardening adhesive between the plates (5) clamped against the fibers (7); grinding the end surface of the plates (5) from which the fibers (7) issue; and introducing at least an alignment plug (10) into a respective groove (9).

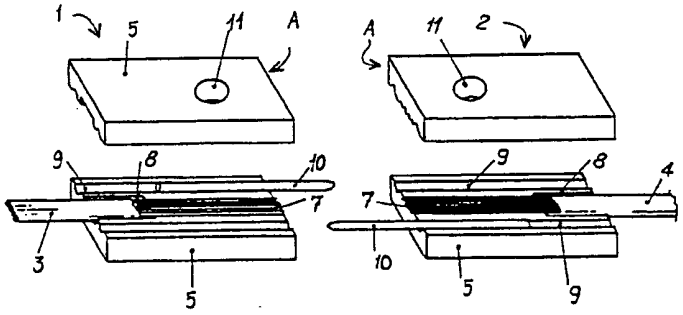

Fig. 1

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DETACHABLE CONNECTING GROUP FOR RIBBON OPTICAL FIBERS AND METHOD OF MAKING THE SAME

The present invention relates to a connecting unit for ribbon-joined optical fibers and to a method of making the same.

For connecting two optical cables of the "ribbon type" to each other, that is cables in which several optical fibers are disposed parallelly to each other and united together by a single plastics coating so as to form a ribbon and one or more ribbons are joined to form the cable, it is necessary to dispose each optical fiber of a ribbon forming one cable in alignment with the corresponding fiber of a ribbon forming the other cable, so as to allow light to pass from one fiber to the other while minimizing dispersions and attenuations of the transmitted signal resulting from faults in fiber alignment.

In order to achieve such alignment simultaneously in all fibers forming the ribbon, the end of the ribbon itself is conveniently fitted into a rigid body, referred to as connector, which keeps the fibers in a geometrically definite position; two connectors forming a pair are therefore disposed and held in a confronting relationship and so aligned that the respective fibers can take the correct position for forming the optical connection.

Due to the requirements for a connection in which the best alignment between all the fibers of the ribbon is achieved in order to limit the attenuation of the light signal to the most when passing through the connection, it is necessary to dictate very reduced tolerances as regards possible coaxiality faults between the fibers of each interconnected pair and, as a result, very reduced tolerances in the sizes and positions of the housings for the fibers themselves in the connectors; in particular, by way of example, for connecting ribbons made of single-mode fibers in which the diameter ϕ of the cladding of each fiber is 125 μm and the mode diameter is equal to 9.5 μm, the position fault of the axis of a fiber in a connector related to the axis of the corresponding fiber in the faced connector indicatively must not be higher than one so that in most cases the signal attenuation at the connection is lower than 1 dB, which is deemed to be the maximum admissible loss value in the connection.

Making connectors having these accuracy requirements is quite a delicate operation, taking particularly into account th fact that it is necessary to produce a great number of connectors to be matched, while ensuring the same qualitativ alignment value to all of them.

For the purpose connectors are known in which the optical fibers are housed inside the grooves of a plate made of a crystalline material which are obtained during several steps by localized etching, at positions defined by protection templates.

Therefore, in order to achieve the very high accuracy in size required for the housing grooves in a plate, the position and shape of which directly states the axis position of the fiber contained therein, particularly delicate and expensive working processes are required in producing said plates.

Also known are (see Europeant Patent Application EP 0 241 724) optical connectors with coupling plugs comprising a base plate provided with grooves to receive the optical fibers and guide plugs to which a flat plate of smaller sizes is fastened; the plates define holes between each other and into said holes the guide plugs and fibers are subsequently introduced.

In order to make the fitting of the fibers in the respective holes possible, the base plate has an uncovered portion the grooves of which represent a guide for the introduction of the fibers.

These connectors are made of a hard and brittle material, such as crystalline silicon or ceramics and the grooves are formed by removal of material by means of very precise grinding machines adapted to ensure the requested tolerance values, necessary for the optical coupling of the fibers.

For the achievement of connectors of this kind particular working techniques and machineries to be used for producing each individual base plate are required; in addition the plates can exhibit differences in sizes resulting from the precision limits offered by the machines used for their production, because it is particularly complicated and expensive to keep these machines within the admissible tolerance values for an optical acceptable coupling.

Furthermore, in the connectors in accordance with this patent application, by coupling a base plate to a flat plate the accomplishment of elements provided with holes in which the fibers must be subsequently inserted is provided, which means that a certain clearance between the fibers and the related holes, as well as between the plugs and the related holes, is always neaded; this clearence which is necessary for introducing the fibers into the holes, in particular when the operation is carried out on th stocks, is however to the detriment of the precision in the optical alignment at the connection and adds to the other inexactitudes in size, some of which have already been m ntioned above.

Also known is the US Patent No. 3 864 018 in

which connectors are described which consist of identical plates provided with several parallel groov s coupled to each other so as to clamp the interposed optical fibers housed in said grooves and keep them in the desired geometrical position; in this structure however the coupling is provided between two connectors located at the ends of respective optical fiber ribbons through outer alignment elements in contact with the plate surfaces opposite those clamping the optical fibers; as a result fibers between two coupled connectors are subjected to an imperfect alignment due to inexactitudes in the plate thickness which can be hardly avoided and which add to the other working inexactitutes of the grooves.

As a result, the structure in accordance with this patent is only adapted to connectors which do not need too much of accuracy, in the case of multimode fibers for example.

Therefore the present invention aims at solving the technical problem involving the accomplishment of connecting elements capable of ensuring a very precise optical alignment in connections, while avoiding the alignment faults due both to the working tolerances and to the presence of clearances between the fibers and the respective guide housings, by adopting a process entailing relatively low costs, and at the same time ensuring the interchangeability between the connectors of each series and where the connectors can offer a faultless mounting whether it is carried out at the factory or on the stocks.

It is an object of the present invention a detachable connecting group for ribbon-joined optical fibers comprising two connectors integral to the ends of respective optical fiber ribbons consisting of at least two parallel optical fibers enclosed in a single outer coating, each connector being provided with a coupling face in contact with the corresponding face of the other connector, the fibers being in alignment and on which coupling face the ends of the optical fibers of the respective ribbon come out, characterized in that each connector consists of a pair of coupled plates rigidly fastened to each other and clamping two or more optical fibers belonging to a ribbon made of parallel optical fibers as well as an alignment plug means, at least one plate in each connector comprising an element made of a plastically deformable metallic material provided with housing grooves for the optical fibers of the ribbon from which the common coating has been removed and for the alignment plug means, which grooves have been formed therein by cold plastic deformation using th same punch for all the plates being part of an interchangeable series, the alignment plugs and the fibers of the fiber ribbon being accommodated within the respective grooves with a portion projecting to the outside of the grooves, an empty space being left between the faced surfaces of the connector plates clamping the fibers and the alignment plugs, into which space a m tered amount of adhesive resin susceptible of hardening is introduced.

At least a plate for each connector has a pair of alignment grooves of substantially triangular section on one surface thereof, which grooves are adapted to partially accommodate respective alignment plugs. Located between these alignment grooves are two or more grooves of substantially triangular section adapted to partially receive corresponding optical fibers of a fiber ribbon from which the common coating has been removed (bare optical fibers), the grooves being formed by cold plastic deformation.

Each plate at one end thereof has a slot adapted to accommodate a length of coated optical fiber ribbon contiguous to the bare fiber length located in the grooves.

The slot in each plate provided with grooves is made at a definite position with respect to the longitudinal orientation of the plate at the moment of forming the grooves.

Preferably the slots in the plates are alternatively formed at either end of the plates, depending upon the longitudinal orientation of the plate when the grooves are being formed, an identification means for recognizing this orientation being present on the plates at the forming.

The identification means for recognizing the orientation of the plates at the forming consists of marks associated with the plate and independent of the respective grooves, said marks comprising side notches, colourings, side asymmetries and the like; said means may also be embodied by differently sized grooves designed to house the alignment plugs in each plate.

The positions of the slots relative to the orientation of the plates define two groups of plates, designated as right and left plates respectively, two connectors being coupled to each other with at least a respective right plate in alignment with a left plate.

According to a preferred embodiment, each connector is formed with two plates each having a surface provided with grooves adapted to accommodate alignment plugs and optical fibers, the plates being coupled to each other so that the respective grooved surfaces are faced and the grooves are in register, the grooves which in each plate are designed to accommodate the plugs and the optical fibers being dimensioned so as to receive said plugs and fibers with the respective axes in coplanar relation, overlying the surface of the plate itself in which the grooves are formed.

In this embodiment each connector is formed with two plates, left and right respectively.

At least the plate grooves adapted to accommodate th optical fibers have sides with flat portions, at least at the ar a in contact with the fibers, forming a dihedral the apex angle of which ranges between 80° and 100°.

At least a plate for each connector has a hole in the middle for inserting metered adhesive material susceptible of hardening between the plates of the connector itself.

According to an alternative embodiment a connector is formed with a plate having one surface provided with grooves adapted to receive alignment plugs and optical fibers coupled and fastened to a plate of identical width having a flat surface in the area overlying the fibers, the optical fibers being clamped between the groove sides and said flat surface.

The grooves designed to receive the plugs and the optical fibers in each grooved plate can be dimensioned so as to receive the plugs and fibers with a common tangent plane, in each connector the grooved plate being coupled to a plate having one flat surface in contact with the fibers and the alignment plugs.

In the above embodiment the two coupled connectors have a plate provided with right grooves and a plate provided with left grooves respectively.

According to a modification to the preceding embodiment, the grooves adapted to receive the plugs and the optical fibers in each grooved plate are dimensioned so as to accommodate the plugs and optical fibers with the respective axes in coplanar relationship, the grooved plates being each coupled to a plate having recessed surfaces at the respective contact areas with the alignment plugs.

In this modified embodiment, the slots in the grooved plates can be alternatively formed at either end of the plates depending upon the longitudinal orientation of the plate when the grooves are formed and two connectors having a right grooved plate and a left grooved plate respectively are coupled to each other as in the preceding case, or said slots can be formed on the same side relative to the orientation of the plates when the grooves are formed.

In the preceding two modifications of the alternative embodiment, at least the grooves in the plates adapted to receive the optical fibers have sides with flat portions, at least at the area in contact with the fibers, forming a dihedral the apex angle of which ranges between 50° and 90°.

Preferably the plat having a substantially flat surface in th area overlying the fibers, at its portions designed to overlie the alignment plugs is provided with respectiv areas having a reduced thickness so as to allow the elastic flexional deformability of said portions.

The method of accomplishing connectors for detachable connecting groups to be used wit ribbon-joined optical fibers is characterized in that it comprises the following steps: making a punch having a predetermined profile comprising several parallel or substantially parallel ridges; forming a plurality of plates made of metallic material with said punch by cold plastic deformation, said plates on one face having an impression corresponding to the punch and provided with several parallel or substantially parallel grooves; accommodating the optical fibers belonging to an optical fiber ribbon, on a length of which the common coating has been removed, into some of the grooves of one plate inside which they are partially contained; associating a grooved plate with a second plate, clamping the fibers between the associated plates; applying a metered amount of adhesive susceptible of hardening between the two plates and keeping the plates clamped against the optical fibers until the adhesive has hardened; grinding the surface of the assembly where the fiber ends come out; and introducing at least an alingment plug into one of said grooves clear of said optical fibers.

The punch at least for one series of grooved plates is unique and common to all the grooved plates.

In addition and conveniently the method provides for the grooved plates produced by the punch to be periodically controlled, the punch being replaced when the groove sizes come close to the predetermined tolerance values.

On the grooved face of a plate before its being joined to the other plate a slot is formed by removal of material at a definite location relative to the orientation of the plate during the formation of the grooves.

Applied to the grooved plate is an identification mark relative to the position of the slot with respect to the orientation of the plate when the grooves are formed.

According to the method of the invention, two grooved plates made with the same punch and in which the slots are located at opposite positions relative to the orientation of the plate when the grooves are formed, can be associated with each other, so as to clamp the optical fibers of the optical fiber ribbon.

Alternatively, a grooved plate and a plate with a flat surface in the area overlying the fibers can be associated with each other.

Further details of the invention can be drawn from the following description of an embodiment thereof made with reference to the accompanying drawings, in which:

- Fig. 1 is an exploded view of a connecting group for optical ribbon-joined cables in accordance with the invention, consisting of two con-

nectable connectors;
- Fig. 2 is a front view of a connector;
- Fig. 3 shows a punch adapted to form the grooved plates according to the invention;
- Fig. 4 shows the working steps for the formation of the grooved plates by use of the punch shown in Fig. 3;
- Fig. 5 shows the working steps for the formation of the slots in the grooved plates and how the pairing of the plates takes place;
- Fig. 6 is a top view of a plate after coining (or plastic metallic deformation) when center-to-center faults are present;
- Fig. 7 shows a pair of plates in the working state seen in Fig. 4 and oriented for the subsequent working;
- Fig. 8 shows a pair of plates faced to form a connector in the presence of center-to-center faults, in a wrong coupling position;
- Fig. 9 shows the connector seen in Fig. 8 with properly coupled plates;
- Fig. 10 shows the corresponding plates of two connectors designed to be coupled to each other, under a condition of wrong orientation;
- Fig. 11 shows the plates of the connectors seen in Fig. 10 in a correct orientation;
- Fig. 12 is a perspectic view of a pair of correctly faced connectors;
- Fig. 13 is a front view of a connector, according to a different embodiment of the invention;
- Fig. 14 is a front view of a connector, still in another embodiment;
- Fig. 15 shows two connectors faced to each other according to the embodiment of Fig. 13;
- Fig. 16 shows a pair of concordantly oriented plates, having parallelism faults;
- Fig. 17 shows a pair of connectors formed with the plates viewed in Fig. 16 faced to each other and showing coincident outlet positions of the grooves;
- Fig. 18 is a perspective view of the connectors shown in Fig. 17.

As shown in Fig. 1, in accordance with the present invention the connection between two optical fiber ribbons is made by means of a pair of connectors 1, 2 integral to the corresponding ends of optical fiber ribbons 3, 4, disposed in confronting relationship with respect to each other; the connectors are accommodated in an outer housing or at all events kept in mutual contact by an outer retaining means not shown as it is not part of the present invention.

Each connector, shown in an exploded view in the drawings, consists of a pair of plates 5 equal to each other and provided with longitudinal grooves 6 into which the optical fiber bare ends 7 (that is the lengths devoid of the protecting coating plastics material so that the outer layer or cladding of the optical fibers is exposed) of ribbons 3, 4 are placed; a slot 8 formed at the end of the plate allows th end portion of th plastics coating of greater thickness to be housed therein.

In addition a pair of further longitudinal grooves 9 receives the plugs 10, preferably one for each connector, designed to be introduced into the corresponding grooves of the other connector and through which the connectors themselves are coupled to each other so that an alignment condition in the connection is created.

The structure of a connector in accordance with the invention is shown in greater detail in figure 2: each plate 5 has several grooves 6 with a V-shaped sectional outline, within which the optical fibers 7 of the ribbon-joined cables 3 or 4 are received; when two plates 5 are paired the fibers 7 are held within the inclined planes of the grooves themselves, their geometrical position being defined by the conformation of the grooves.

The depth of grooves 6 is established depending upon the outer diameter ϕ of the fiber, so as an empty space s of predetermined value between the plates may be left; as the plates are identical with each other, the axis a of the core of each fiber is disposed in an intermediate position between the plates.

One of the plates forming a connector or both of them are provided with a hole 11, more clearly shown in Fig. 1, through which a metered amount of adhesive hardening resin 12 is cast between the two plates 5 held tightened against the fibers 7 according to a predetermined strength. Said metered amount of resin fills the empty space of thickness s between the plates as well as the space between the grooves 6 clear of the fibers, rigidly clamping the two plates to each other and the fibers contained therein; the amount of adhesive is provided so that it may fill the area between the plates involving the fibers without however reaching the grooves 9 so that the introduction thereinto of the plugs 10 is not hindered.

When the adhesive resin has hardened, the front surface A of the connector thus formed, designed to carry out the contact with the corresponding surface of the connector mounted to the end of the other cable is submitted to a grinding operation ensuring the perfect flatness and smoothness of the optical fibers to be connected.

The plates 5 are made of a metallic material by cold plastic deformation, also referred to as coining.

The next steps for the accomplishment of plates and connectors are diagrammatically shown in Figs. 3, 4, 5.

By known and conventional workings, which therefor are not further described in detail herein, a punch P is manufactured as shown in Fig. 3,

which is provided with projecting ridges C, C′ adapted to form the desired grooves in the plat s.

Starting from a flat plate 5a made of brass or aluminium, or at all events of a material having sufficent stiffness and capable of undergoing a permanent cold plastic deformation by a punch, or starting from a ribbon made of the same material and of identical width and thichness to be subsequently cut according to the desired length, the grooved plates 5b are coined by the punch P, in which plates grooves 6 and 9 are extended over the whole length of the same.

The grooved plates 5b are then machined, for example milled, so as to form the slots 8 therein as shown in Fig. 5 in order to create plates ready to be mounted, generally identified by reference numeral 5.

Plates 5 can therefore be coupled to each other, as previously described, and therefore give rise to a finished connector.

The grooved plates 5 are coined in the desired number by the punch P which is obtained by mechanical high precision working; by virtue of the above procedure, plates 5 are strictly equal to one another, at least as far as a great number of pieces produced with the same punch before its being worn are concerned, and therefore as regards the connectors formed with said plates a complete compatibility and interchangeability is ensured with a very reduced attenuation of the transmitted signal.

As the punch is of one piece construction, it can be worked in a very precise manner; on the other hand, the connectors formed by adopting the above method can ensure the coupling with the fibers in a condition of perfect alignment, as previously stated, even if the punch does not offer very high qualities as regards accuracy in size, in particular as far as the pitch between the grooves is concerned.

In particular, by forming the punch through a common mechanical precision working, in which the ridges adapted to give rise to the grooves 6, 9 in the plates coined by said punch are for example formed by a grinding operation on the punch itself, it is usually possible to keep a satisfactory degree of parallelism between the ridges, and therefore between the plate grooves, whereas the precision of the machine tool used can be insufficient to ensure the center-to-center constancy between the different ridges of the punch, because the required tolerance is very reduced.

In this case, as shown in Fig. 6 where faults are magnified for the sake of graphic clarity, between the different grooves 9 and 10 it will be possible to have the following distances between centers d_1, d_2, d_3, d_4, d_5 the values of which deviate from the expected th oretical values.

According to the present invention, two id ntical plates obtained with the same punch ar coupled to each other; in this way a possible lack of precision in the distance between the centers of two grooves can be ignored because the real center-to-center values are at all events kept constant in the different pieces.

For the purpose two identical plates made with the same punch are overlapped as shown in Fig. 9; by overlapping the sides of the plates also the grooves are disposed so as to be coincident; on the contrary in case of reverse overlapping, as shown in Fig. 8, the grooves will be no longer coincident and the correct mounting of the fibers in the grooves will be prevented.

In order to ensure a correct mounting of the plates according to the arrangement shown in Fig. 9, the plates after coining are given an appropriate orientation, a front part and a rear part being established for each of them, that is a surface designed to face the contiguous connector and an opposite surface designed to receive the fiber ribbon when a connector is formed with said plate; it results therefore that for a correct coupling the plates to be coupled must be selected with opposite orientations with respect to the direction according to which they have been coined.

This "front-rear" orientation can be conveniently defined by the slot 8 which can univocally establish the surface in the plate where the fiber ribbon is to be inserted; as shown in Figs 5 and 7 a correct overlapping can be achieved with plates in which the grooves 8 are oriented in opposite ways with respect to the direction of the plates themselves at the coining, shown by arrows F.

In order to ensure the acknoledgement of the plates to be coupled, after their front-rear orientation they are also identified as right (D) and left (S) plates, with reference to the arrangement of the front and rear surfaces relative to the plate orientation at the coining.

For the purpose the identification of the plates can take place by means of marks etched on one of the sides, or different colourings, shapes or the like; for example a notch 13 always etched on the same side relative to the coining orientation of the plates identified by arrow F is shown in Fig. 7.

The notch 13 can then be disposed to the right of a person regarding the plates in the above defined front-rear direction or to his left as shown in Fig. 7 on the upper and lower plates respectively.

Under these conditions by coupling a right plate to a left plate so that slots 8 and notches 13 are on the same side, it is possible to have coincident grooves as shown in Fig. 9, which makes the acknoledgement of the correct mounting of the plates to form a connector easy.

According to a further embodiment, the acknowledgement and correct coupling of right and left plates can be achieved by providing asymm trical alignement plugs, for example plugs having different diameter depending whether they are located to the right or to the left of the fibers: in this case, being the slots 8 formed as shown in Fig. 7, an incorrect mounting of the plates appears impossible or at all events can be immediately recognized as the introduction of the plugs into the respective grooves is prevented.

The same remarks as above are valid for the alignment of two connectors formed with the above described plates when the grooves have center-to-center faults: two corresponding plates in two connectors to be joined, when brought into alignment by plugs 10 and grooves 9 the axes of which are outlined by chain dot lines in the figures do not have grooves 6 in mutual alignment if they are homologous, if they are both left (S) plates for example as shown in Fig. 10, whereas said grooves 6 are in mutual alignment if a left type (S) plate and a right type (D) plate are brought into register with each other, as shown in Fig. 11.

Therefore, as shown in Figs. 5 and 11 for a correct coupling between connectors, the plates of the two connectors to be coupled must have opposite arrangement, that is a left (S) plate must always face a right (D) plate.

For example, as shown in Figs. 7 and 12, it is possible to see if the notches 13 of each connector are placed in register with each other and if the notches in two connectors to be coupled are on the same side and therefore perform a correct mounting; in case of use of alignement plugs having different sizes or sections, the junction of two connectors can only take place when they have a correct arrangement.

By adopting coining, it is possibile to accomplish the most convenient profile for the grooves 9 and 6, as well as to enable the desired alignement of the fibers even in the presence of working imprecisions in the punch; in particular, in order to make the contact lines between the outer surface of the fibers 7 and the planes in which the grooves 6 are contained equally spaced apart from each other, a groove section in the form of an isosceles triangle is preferred, in which the apex angle α is in the range of 80° to 100°, and preferably equal to 90°.

The bottoms of grooves 9 and 6, beyond the area in which they may interfere with plugs 10 and fibers 7 respectively, can be radiused, bevelled or relieved, depending upon the working requirements of the punch and so on; similarly the edges between the groove sides and the plate plane in areas far apart from the contact positions with the fibers or plugs, can be radiused or chamfered.

In addition, in case of particular requirements, the grooves can also have differently shaped sides, and curved, stepped or similar surfaces can b provided.

According to an alternative embodiment of the present invention shown in Figs. 13 and 14, it is possible to make a plate 14 or 15 by coining, provided with grooves 16 adapted to receive the fibers 7 and with grooves 17 or 18 for receiving the alignment plugs 10 respectively, and designed to form a connector when associated with a second plate of different form.

In the embodiment shown in Fig. 13 the plate 14 is associated with a covering plate 19 of identical extension having a flat surface; the grooves are formed to such a depth and inclination of the sides that they can receive the plugs 10 while keeping the upper tangent plane thereof level with the tangent plane of the fibers 7.

Since in this case the axis of the plugs 10 is not in coplanar relation with the axis of the fibers 7, when two connectors have to be coupled the corresponding plates 14 and 19 are disposed in confronting relationship with each other according to the diagram shown in Fig. 15; the coupling of the connectors takes place with a right type plate in one case and with a left type plate in the other case, as already defined with reference to the diagram shown in Fig. 7.

This embodiment allows the fibers and plugs to be received between three planes, so that redundant engagements are avoided and in this case it is only necessary to establish the flatness of the coupling surface to the fibers and plugs, for plates 19.

In the embodiment shown in Fig. 14, on the contrary, a grooved plate is provided which has respective grooves 16 and 18 for the fibers and alignment plugs, which are such dimensioned that the axes of the fibers and plugs are in coplanar relation with each other; associated therewith is an upper plate 20 shaped with a recessed area 21 in the region of each plug, which allows fibers 7 and plugs 10 to be simultaneously clamped in the respective grooves while keeping the corresponding axes in coplanar relation.

In making the plate 20 the high size precision dictated for carrying out the grooves in plate 15 is not necessary; in fact the width of areas 21 can have a wide tolerance while a fault in the distance between the plane of the area 22 in contact with the fibers and the plane of the areas 21 in contact with the plugs can be compensated for, due to a flexional elastic yielding of the plate in its recessed areas 21 in the region of plugs 10, the position of the plug axis being ensured by the geometrical precision of grooves 18.

In order to reduce the rigidity of plate 20 where

required, so as to increase th flexional deformability of the plate itself, portions of reduced thickness in the plate can be provided and they ar represent d by grooves, cuts or th lik 24 facilitating the localized bending of the plate side portions 21 overlying the plugs without transmitting important stresses to the area 22 overlying the optical fibers.

It may be convenient to provide a certain interference value between the plug 10 and the plane of the area 21 beforehand, in order to ensure a frictional engagement of the plug in its housing.

Likewise, plate 19 shown in Fig. 13 can be conveniently provided with side portions 25 overlying the alignment plugs 10 susceptible of elastic yielding, due to the presence of grooves or cuts 26 defining areas of reduced thickness 27 parallel to the grooves 16 and 17 and extending over the whole length of the plates along which the plate bending can take place without giving rise to strong stresses; alternatively, the whole extension of the side portions 25 can be of reduced thickness, as shown in dotted lines in the figure.

The material to make the plate 19 or 20 can be different from that of the underlying grooved plate 14 or 15, so as to exhibit a flexional behaviour particularly suitable to the desired degree of elastic clamping for the plugs.

Due to the more reduced precision requirements needed for the execution of plates 19 or 20, they can be made using different techniques, by drawing for example, and a grinding operation can be provided, if necessary, for the only area designed to get in contact with the optical fibers.

The embodiment shown in Fig. 14 and providing for the alignment plugs 10 to be arranged so that their axes are in coplanar relation with the axes of the optical fibers 7 may be particularly convenient when a fault also in the parallelism between the plate grooves is feared as diagrammatically shown in Fig. 16 where faults are magnified and in which two plates made with the same punch and concordantly oriented as shown by arrow F are represented; in fact, as diagrammatically shown in Figs. 17 and 18, it is still possible to achieve the coincidence between the fiber housing grooves in the faced plates by using plates identical with each ohter to form the two connectors to be coupled and disposing a connector in such a manner that its respective plate 15 is overturned with respect to the corresponding plate 15 of the other connector and consequently the ends of the corresponding fibers can be correctly disposed in confronting relationship; the possible angle between the fibers has no consequences, as at all events its value is lower than a value susceptible of producing important attenuations in the transmitted signal.

In the embodiments shown in Figs 13 and 14 th opening angle β of the dihedrals forming the grooves 16 adapted to receive the fibers and grooves 17, 18 receiving the plugs is preferably in th rang of 50° to 90°, while differ nt angles can be used for particular reasons.

Many variations can be made without departing from the scope of the present invention taken in its general features.

Claims

1. A detachable connecting group for ribbon-joined optical fibers, comprising two connectors (1, 2) integral to the ends of respective optical fiber ribbons (3, 4) consisting of at least two parallel optical fibers (7) enclosed in a single outer coating, each connector (1, 2) being provided with a coupling face in contact with the corresponding face of the other connector, the fibers (7) being in alignment and on which coupling face the ends of the optical fibers (7) of the respective ribbon (3, 4) come out, characterized in that each connector (1, 2) consists of a pair of coupled plates (5) rigidly fastened to each other and clamping two or more optical fibers (7) belonging to a ribbon (3, 4) made of parallel optical fibers as well as an alignment plug means (10), at least one plate (5) in each connector (1, 2) comprising an element made of a plastically deformable metallic material provided with housing grooves (6,9) for the optical fibers (7) of the ribbon (3,4) from which the common coating has been removed and for the alignment plug means (10), which grooves have been formed therein by cold plastic deformation using the same punch (P) for all the plates (5) being part of an interchangeable series, the alignment plugs (10) and the fibers (7) of the fiber ribbon (3, 4) being accommodated within the respective grooves (9, 6) with a portion projecting to the outside of the grooves, an empty space (s) being left between the faced plate surfaces of the connector (1, 2) clamping the fibers (7) and the alignment plugs (10), into which space a metered amount of adhesive resin (12) susceptible of hardening is introduced.

2. A detachable connecting group for ribbon-joined optical fibers according to claim 1, characterized in that at least a plate (5) for each connector (1, 2) has a pair of alignment grooves (9) of substantially triangular section on one surface thereof, which grooves are adapted to partially accommodate respective alignment plugs (10), between these alignment grooves (9) being located two or more grooves (6) of substantially triangular section, adapted to partially receiv corresponding optical fibers (7) of a fiber ribbon (3, 4) from which the common coating has been removed (bare optical fibers), the grooves (6, 9) being formed by cold

plastic d formation.

3. A detachable connecting group for ribbon-joined optical fibers according to claim 2, characterized in that each plat (5) at one end ther of has a slot (8) adapted to accommodate a length of coated optical fiber ribbon (3, 4) contiguous to the bare fiber (7) length located within the grooves (6).

4. A detachable connecting group for ribbon-joined optical fibers according to claim 3, characterized in that the slot (8) in each plate (5) provided with grooves (6, 9) is made at a definite position with respect to the longitudinal orientation of the plate (5) at the moment of forming the grooves (6, 9).

5. A detachable connecting group for ribbon-joined optical fibers according to claim 4, characterized in that the slots (8) in the plates (5) are alternatively formed at either end of the plates (5), depending upon the longitudinal orientation of the plate (5) when the grooves (6, 9) are being formed, an identification means (13) for recognizing this orientation being present on the plates at the forming.

6. A detachable connecting group for ribbon-joined optical fibers according to claim 5, characterized in that the identification means for recognizing the orientation of the plates (5) at the forming consists of marks (13) associated with the plate (5) and independent of the respective grooves (6, 9), said marks comprising side notches, colourings, side asymmetries and the like.

7. A detachable connecting group for ribbon-joined optical fibers according to claim 5, characterized in that said means for recognizing the orientation of the plates (5) at the forming are embodied by differently sized grooves (9) designed to house the alignment plugs (10) in each plate (5).

8. A detachable connecting group for ribbon-joined optical fibers according to claim 5, characterized in that the positions of the slots (8) relative to the orientation of the plates (5) define two groups of plates (5), designated as right (D) and left (S) plates respectively, two connectors (1, 2) being coupled to each other with at least a respective right plate (5) in alignment with a left plate (5).

9. A detachable connecting group for ribbon-joined optical fibers according to claim 2, characterized in that each connector (1, 2) is formed with two plates (5) each having a surface provided with grooves (9, 6) adapted to accommodate alignment plugs (10) and optical fibers (7), the plates (5) being coupled to each other so that the respective grooved surfaces are faced and the grooves (6) are in register, the grooves (9, 6) which in each plate are designed to accommodate the plugs (10) and the optical fibers (7) being dimensioned so as to receive said plugs (10) and fibers (7) with the respective axes in coplanar relation overlying the surface of the plate itself in which the grooves (9, 6) are formed.

10. A detachable connecting group for ribbon-join d optical fibers according to claim 9, characterized in that ach connector (1, 2) is formed with two, left and right respectiv ly, plates (5).

11. A detachable connecting group for ribbon-joined optical fibers according to claim 9, characterized in that at least the plate grooves (6) adapted to accommodate the optical fibers (7) have sides with flat portions, at least at the area in contact with the fibers (7), forming a dihedral the apex angle (α; β) of which ranges between 80° and 100°.

12. A detachable connecting group for ribbon-joined optical fibers according to claim 1, characterized in that at least a plate (5) for each connector (1, 2) has a hole (11) in the middle for introducing metered adhesive material (12) susceptible of hardening between the plates (5) of the connector itself.

13. A detachable connecting group for ribbon-joined optical fibers according to claim 2, characterized in that a connector (1, 2) is formed with a plate (14, 15) having one surface provided with grooves (17, 16) adapted to receive alignment plugs (10) and optical fibers (7) and coupled and fastened to a plate (19, 20) of identical width having a flat surface in the area overlying the fibers (7), the optical fibers being clamped between the groove sides and said flat surface.

14. A detachable connecting group for ribbon-joined optical fibers according to claim 13, characterized in that the grooves (17, 16) designed to receive the plugs (10) and the optical fibers (7) in each grooved plate (14) can be dimensioned so as to receive the plugs (10) and fibers (7) with a common tangent plane, in each connector (1, 2) the grooved plate (14, 15) being coupled to a plate (19, 20) having one flat surface in contact with the fibers (7) and the alignment plugs (10).

15. A detachable connecting group for ribbon-joined optical fibers according to claim 13, characterized in that the two connectors (1, 2) coupled to each other have a plate (14, 15) provided with right (D) grooves and a plate provided with left (S) grooves respectively.

16. A detachable connecting group for ribbon-joined optical fibers according to claim 13, characterized in that the grooves (17, 16) adapted to receive the plugs (10) and the optical fibers (7) in each grooved plate (14, 15) are dimensioned so as to accommodate the plugs (10) and optical fibers (7) with the respective axes in coplanar relationship, the grooved plates (14, 15) being each coupled to a plate (20) having recessed surfaces (21) at the respective contact areas with the alignment plugs (10).

17. A detachable connecting group for ribbon-joined optical fibers according to claim 16, characterized in that the slots (8) in the grooved plates

(14, 15) can be alternatively formed at either end of th plates depending upon the longitudinal orientation of the plate (14, 15) when the grooves (16, 17) are formed, two connectors (1, 2) having a right grooved (D) plate and a left grooved (S) plate respectively being coupled to each other.

18. A detachable connecting group for ribbon-joined optical fibers according to claim 16, characterized in that the slots (8) in the grooved plates (14, 15) are formed on the same side relative to the orientation of the plates when the grooves (16, 17) are formed.

19. A detachable connecting group for ribbon-joined optical fibers according to claim 13, characterized in that at least the grooves (16) in the plates (14, 15) adapted to receive the optical fibers (7) have sides with flat portions, at least at the area in contact with the fibers, forming a dihedral the apex angle (β) of which ranges between 50° and 90°.

20. A detachable connecting group for ribbon-joined optical fibers according to claim 13, characterized in that the plate (20) having a substantially flat surface in the area overlying the fibers (7), at its portions (25) designed to overlie the alignment plugs (10) is provided with respective areas (26, 27) having a reduced thickness so as to allow the elastic flexional deformability of said portions (25).

21. A method of accomplishing connectors for detachable connecting groups to be used with ribbon-joined optical fibers, characterized in that it comprises the following steps: making a punch (P) having a predetermined profile comprising several parallel or substantially parallel ridges (C, C′); forming a plurality of plates (5) made of metallic material with said punch by cold plastic deformation, said plates on one face having an impression corresponding to the punch and provided with several parallel or substantially parallel grooves (6, 9); accommodating the optical fibers (7) belonging to an optical fiber ribbon (3, 4), on a length of which their commom coating has been removed, into some of the grooves (6, 9) of one plate (5) inside which they are partially contained; associating a grooved plate (5) with a second plate (5), clamping the fibers (7) between the associated plates; applying a metered amount of adhesive (12) susceptible of hardening between the two plates (5) and keeping the plates clamped against the optical fibers (7) until the adhesive has hardened; grinding the surface of the assembly (1, 2) where the fiber ends come out; and introducing at least an alingment plug (10) into one of said grooves (9) clear of said optical fibers (7).

22. A method of accomplishing connectors for detachable connecting groups to be used with ribbon-joined optical fibers according to claim 21, characterized in that the punch (P) at l ast for one series of grooved plates (5) is unique and common to all the grooved plates (5).

23. A method of accomplishing connectors for detachable connecting groups to be used with ribbon-joined optical fibers according to claim 21, characterized in that according to it the grooved plates (5) produced by the punch (P) must be periodically controlled, the punch being replaced when the groove sizes come close to the predetermined tolerance values.

24. A method of accomplishing connectors for detachable connecting groups to be used with ribbon-joined optical fibers according to claim 20, characterized in that on the grooved face of a plate (5) before its being joined to the other plate (5) a slot (8) is formed by removal of material at a definite location relative to the orientation of the plate (5) during the formation of the grooves (6, 9).

25. A method of accomplishing connectors for detachable connecting groups to be used with ribbon-joined optical fibers according to claim 21, characterized in that an identification mark (13) is applied to the grooved plates (5) relative to the position of the slot (8) with respect to the orientation of the plate (5) when the grooves (6, 9) are formed.

26. A method of accomplishing connectors for detachable connecting groups to be used with ribbon-joined optical fibers according to claim 21, characterized in that two grooved plates (5) made with the same punch and in which the slots (8) are located at opposite positions relative to the orientation of the plate (5) when the grooves (6, 9) are formed, are associated with each other, so as to clamp the optical fibers (7) of the optical fiber ribbon (3, 4).

27. A method of accomplishing connectors for detachable connecting groups to be used with ribbon-joined optical fibers according to claim 21, characterized in that a grooved plate (14, 15) and a plate (19, 20) with a flat surface at least in the area overlying the fibers (7) are associated with each other, so as to clamp the optical fibers (7) of the optical fiber ribbon (3, 4).

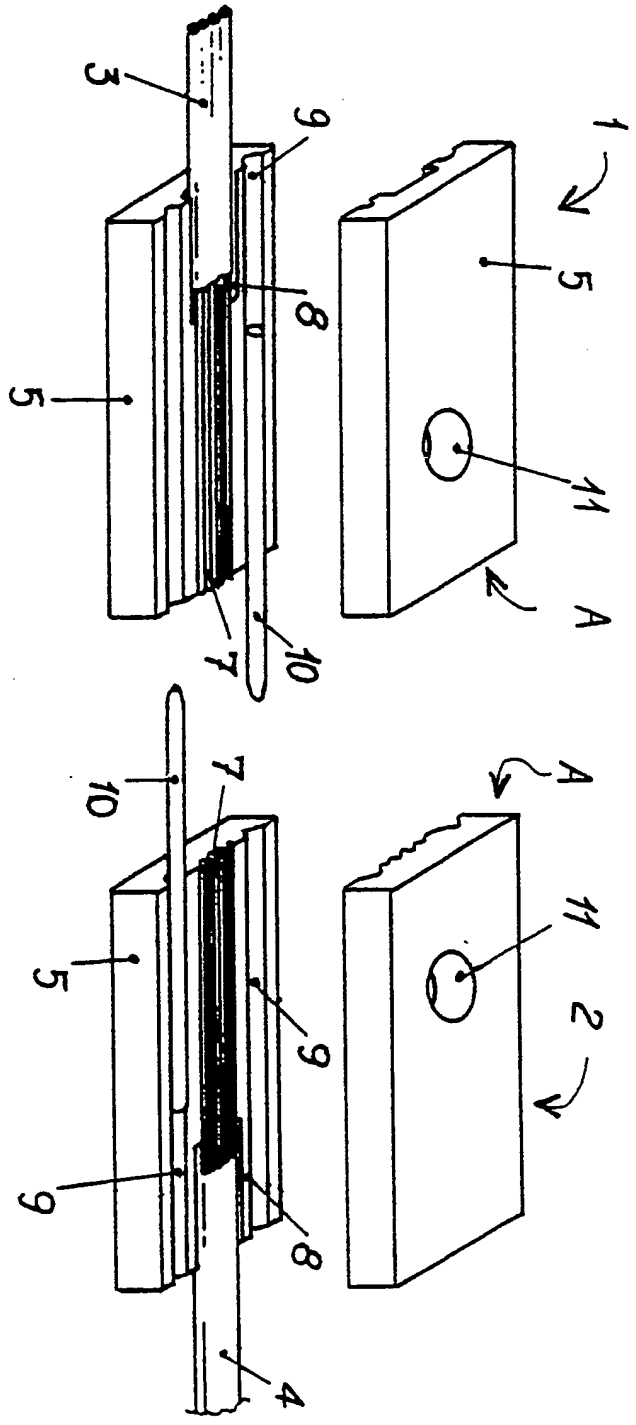
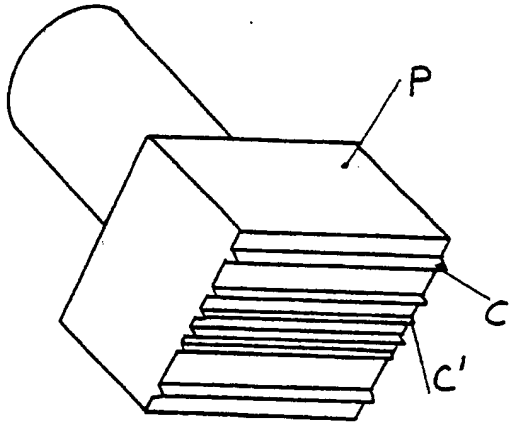


Fig. 1

Fig. 3



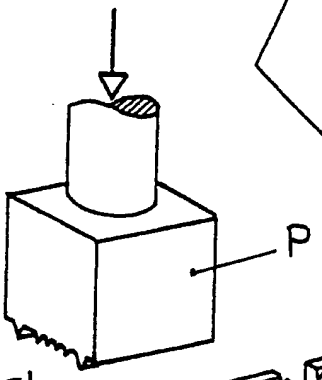
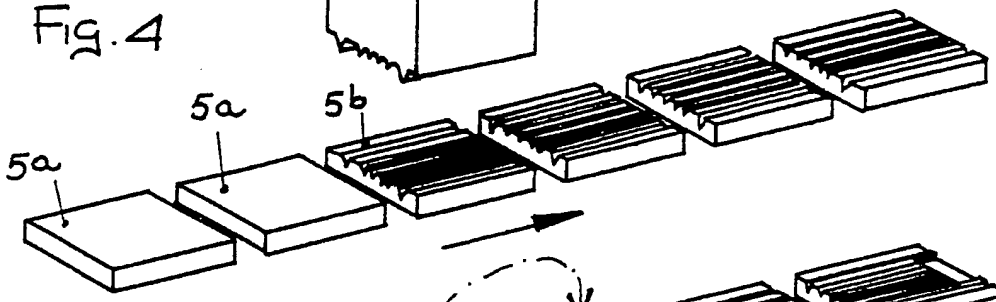


Fig. 4



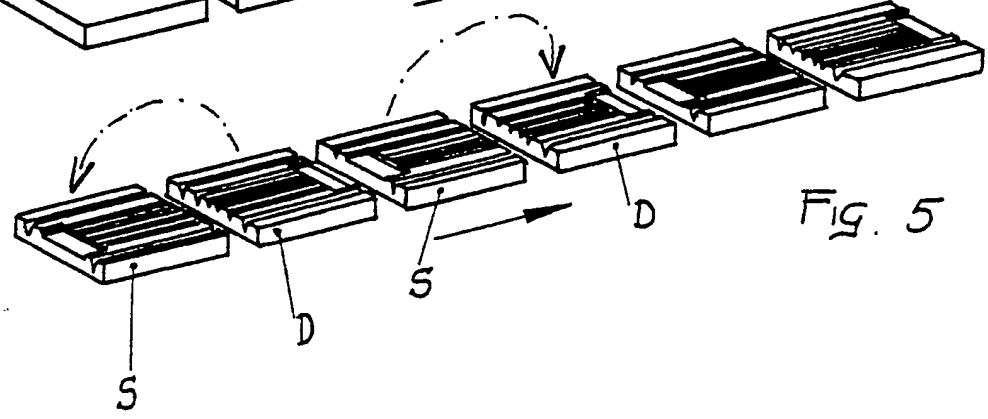


Fig. 5

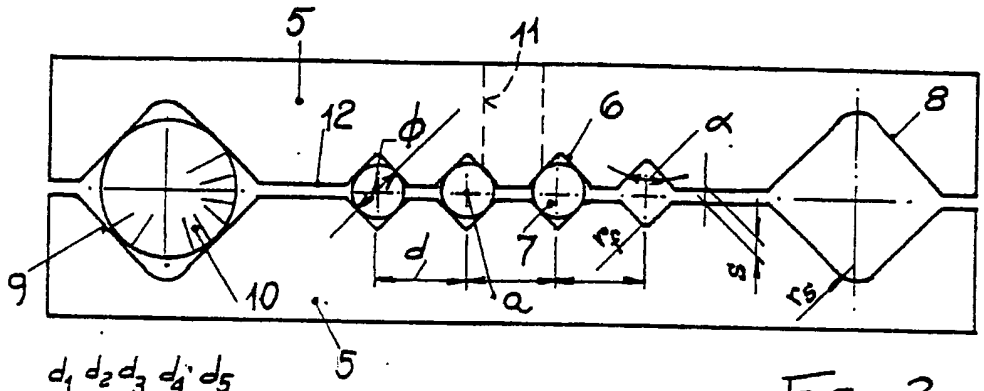


Fig. 2

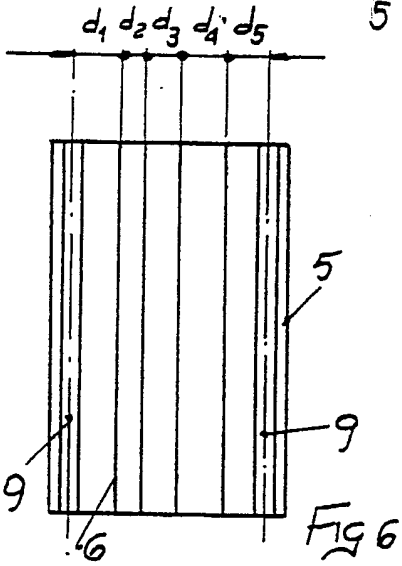


Fig 6

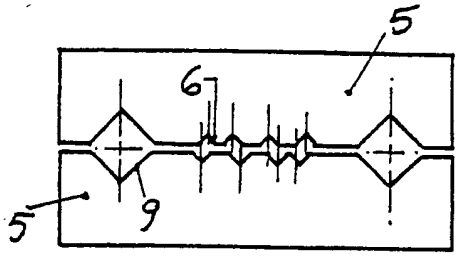


Fig.8

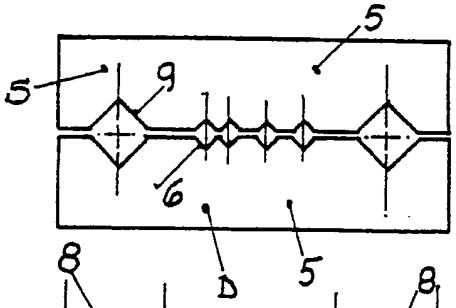


Fig. 9

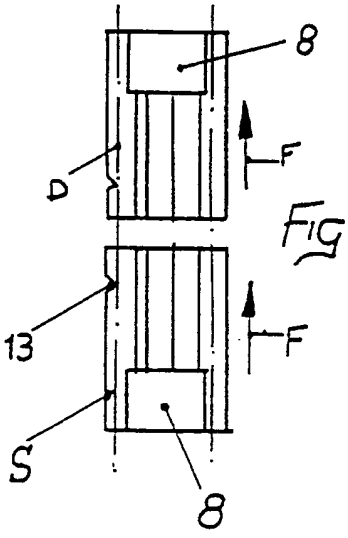


Fig. 7

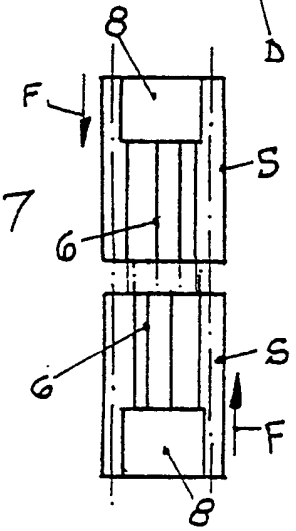


Fig. 10

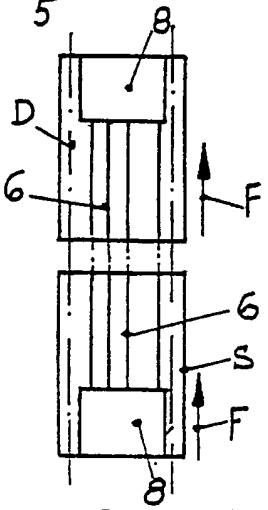


Fig. 11

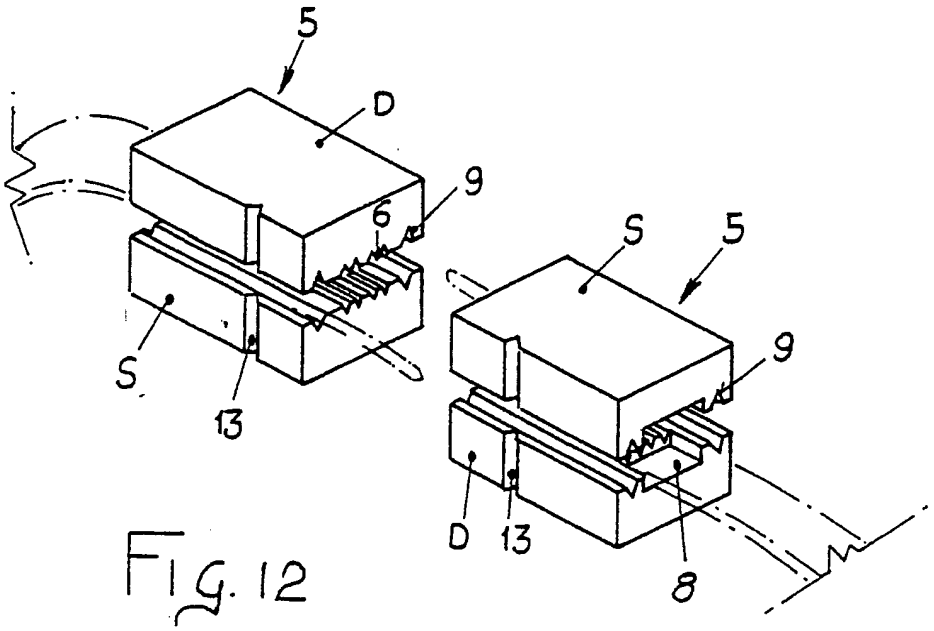


FIG. 12

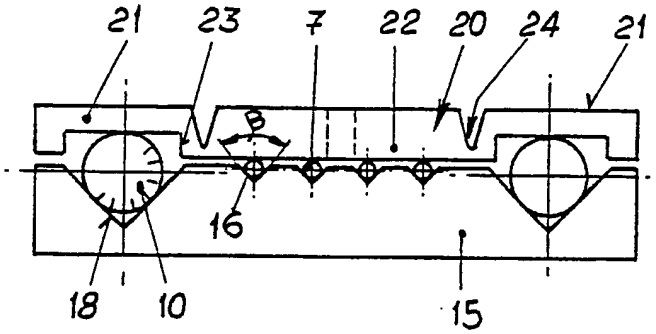


FIG. 14

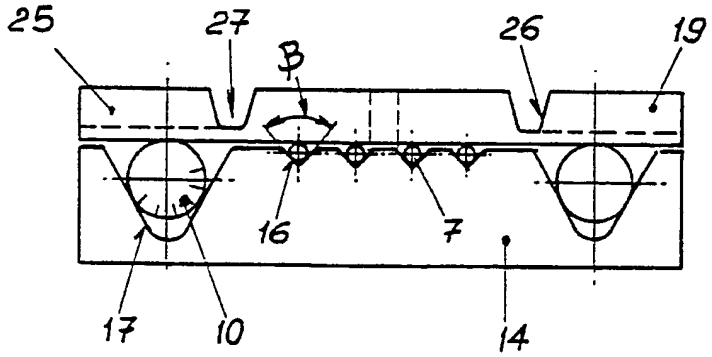


FIG. 13

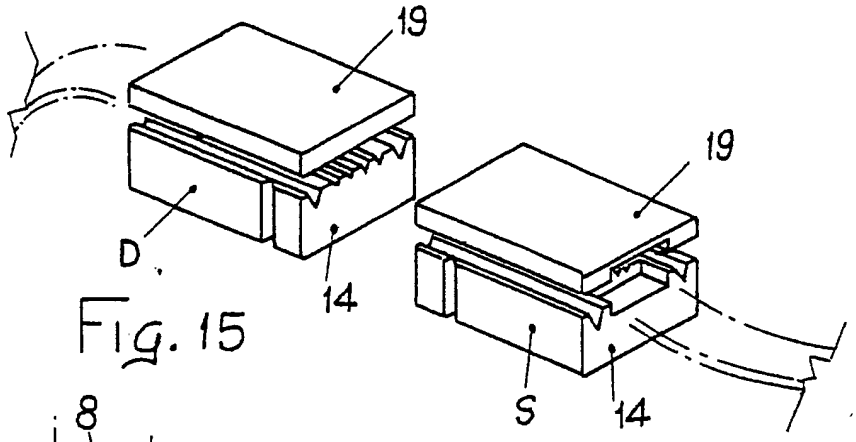


FIG. 15

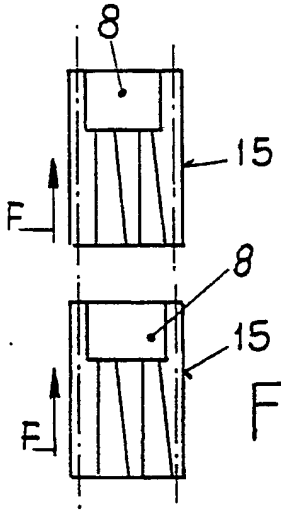


FIG. 16

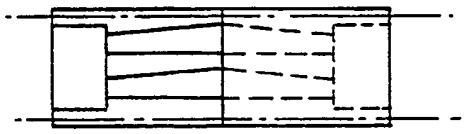


FIG. 17

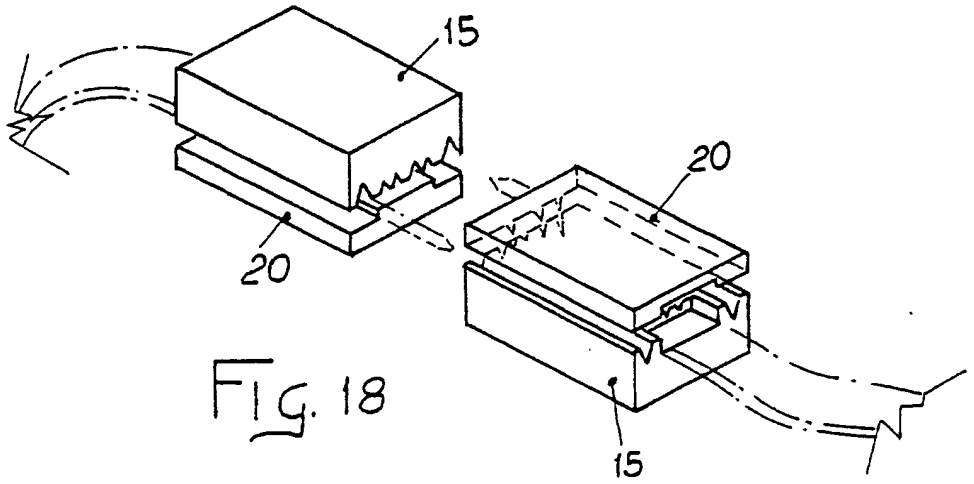


FIG. 18